

Attracting Female Engineers: A Qualitative Analysis in Mechanical Engineering in Germany

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Abstract: The number of women working as engineers in the mechanical and plant engineering sector in Germany has risen to eleven percent in 2023 – remaining at humble levels. In higher positions, the share is even lower. While around 20 % of engineering students at German universities are female, these women do not seem to be entering the sector or they are leaving it again. The question arises as to what companies in the mechanical and plant engineering sector can do to attract female engineers after graduation. This study was conducted in cooperation with the German Engineering Association. The aim was to qualitatively explore the reasons why women enter, stay or leave the engineering sector and to include the industry's perspective to obtain a holistic view of the situation. Therefore, on the one hand the perspective of female engineers was investigated and, on the other hand, combined with the perspective of companies. We provide insights from focus groups and interviews with 49 female engineers across all career levels, from an analysis of 90 online company websites and social media pages as well as from three on-site visits at exemplary companies. The findings point to unresolved issues in recruitment and beyond: highlighting role models of successful women in engineering, the need for companies to actively attract and support women in engineering, e. g. through recruiting strategies focusing on women, insights into the working culture, and transparency regarding career options. Overall, the study suggests that companies should embed gender diversity and group specific recruitment as important issues in their organizations. Consequently, the study provides recommendations for action for companies seeking to become a more inclusive and diverse industry. Limitations are discussed and further implications are presented.

Keywords: Women in Engineering, Female Students, Diversity Recruiting, Gender Diversity, Qualitative Research

1. Introduction

Recruiting and retaining women is a challenge for many companies in the engineering sector. Despite the promotion of a higher number of female engineers since the mid-1990s (Ceci et al, 2014), the proportion of female engineers has not been increasing significantly (Anger et al, 2021). With a share of eleven percent in 2023, women are still underrepresented in German mechanical and plant engineering, a sector that is strongly characterized by medium-sized and family-owned companies (VDMA, 2022). Moreover, demographic change is exacerbating the urgency of the shortage of professionals in STEM (science, technology, engineering, and mathematics) subjects. However, increasing the share of women in the engineering sector promises more than just overcoming the shortage of skilled workers, since heterogeneous teams are more innovative and have a competitive advantage (Somech & Drach-Zahavy, 2013).

In recent decades, a considerable amount of research papers has been published discussing possible reasons for the low share of women in STEM subjects and careers. However, German mechanical and plant engineering companies seem to face problems addressing and winning female engineers to start their career in their facilities. Therefore, the question arises which reasons female engineers might have (not) to enter these companies. What is more, the companies require concrete measures to address and win women at the transition from study to work.

Therefore, we ran a qualitative study inquiring both female engineering students and engineers as well as companies. In the following, the current state of research is presented and the objective and research questions are derived.

2. Research Results on the low Share of Women in Engineering

The first barrier for the low share of women in German mechanical and process engineering courses is already rooted in the choice of study program. Although the number of female freshmen in German engineering programs has been increasing in recent years, in 2020 only 22.5 % of engineering freshmen were female (Anger

et al, 2021). Numerous studies have examined the influence of social environment in childhood, early socialization, and the conveyance of stereotypical gender roles on the later academic and career choices of girls and boys (Olsson & Martiny, 2018). They show that girls' self-perception and their assessment of their technical and mathematical skills are strongly influenced by their social and educational environment and strongly influence their later career choice (acatech & Joachim Herz Stiftung, 2022; OECD, 2015; Weinhardt, 2017). In addition to gender-specific stereotypes, anticipated and experienced male-dominated corporate cultures as well as a lack of female role models lower the interest of young women in STEM programs (González-Pérez et al, 2020). In addition, it is assumed that a lack of knowledge and insight into the engineering profession through internships or vacation jobs contributes to the perception that the job is boring and complicated, and not very social or creative (Seron et al, 2016). These influences maintain prominent during the women's time at university. For example, despite having the same competencies, female engineering students tend to perceive their suitability for the field lower than their male counterparts do (Mastekaasa & Smeby, 2008). The self-doubt of women regarding their suitability often leads to premature termination of their studies or complete abandonment of the industry (Dunlap & Barth, 2019). At the same time, successfully completing a STEM degree does not mean that graduates will pursue a career in the engineering sector. As a result, despite an overall increase in the number of female graduates, the share of female engineers in mechanical and plant engineering remains relatively low, currently comprising only eleven percent (VDMA, 2022). This prevailing gap between the proportion of female graduates and female engineers in the industry underscores the importance of examining hindering and facilitating factors at the transition from study to professional entry.

Aggravating the situation, women are continuously leaving the industry during their professional careers (Singh et al, 2018). The possible reasons for this are diverse and subject to individual expectations, preferences, and characteristics of a person as well as environmental influences from the employer, family obligations, or partnership (Werz et al, 2021). For instance, women may face obstacles to re-enter after maternity leave, encounter challenges in male-dominated work environments and accessing professional networks (Martin & Barnard, 2013). The entrenched "culture of engineering" preserves a masculine professional identity, ultimately contributing to the underrepresentation of women in leadership roles (Carberry & Baker, 2018; Stemmer, 2020).

Amidst these complex interrelations, the transition from study to work represents a potential fracture point, despite being the decisive moment for attracting women for the industry. Previous studies have provided limited information regarding the motives behind individual career decisions, trajectories, and interruptions. Additionally, there is a lack of insight into the perspective of companies' motives and actions in this matter. Addressing these research gaps is the objective of this study. Therefore, it examines both facilitating and inhibiting factors from the perspectives of female engineers as well as from the perspective of companies, with a specific focus on the transition from study to career. This helps to identify the challenges to increasing the proportion of female engineers in the engineering sector and derive concrete recommendations for action to support companies in attracting and retaining female engineers in mechanical and plant engineering.

Thus, the research questions (RQ) of this study are:

RQ 1: What are the facilitating and hindering factors of prospective and working female engineers with regard to the transition between studying and working?

RQ 2: What challenges and opportunities arise for the design of the transition from study to career from the perspective of companies?

3. Method

This study was conducted in cooperation with the German Engineering Association (IMPULS Foundation as part of the VDMA e.V.). The following section provides an overview of the participants and the methodological approach for both the female engineers' perspective and the company perspective. Figure 1 depicts the comprehensive procedure of the current study.

3.1 Perspective of Prospective and Practicing Female Engineers

In total, n = 49 prospective, current, and former female engineers in the engineering sector were interviewed in a variety of qualitative formats (see figure 1). To gain the perspective of prospective female engineers, three virtual focus groups were conducted with n = 19 female students (four master students, 15 bachelor students) from various engineering and related disciplines (31.58 % mechanical engineering, 26.32 % computer science, 15.79 % industrial engineering, 15.79 % mechatronics, 10.52 % other engineering subjects). The age of

participants was $m = 23.37$ years, $SD = 3.45$. In addition, 23 currently employed (91.3 %) or former (8.7 %) female engineers from the mechanical and plant engineering sector were interviewed. The age of interviewees was $m = 38.05$ years, $SD = 10.12$. Moreover, seven female engineers working as research associates participated in a focus group addressing engineers at universities.

During the focus groups, the prospective female engineers discussed their university and company experiences, and evaluated company websites and job advertisements for attractiveness and interest. The three-hour event took place online and with the help of a virtual collaboration board. The one-to-one interviews with currently employed or former engineers covered five key topics, such as their career trajectories, selection criteria when looking for a job and the role of the company's external image. In the two-hour focus group with female researchers, they discussed the factors that made them pursue a scientific career and their future career plans.

Women's perspective: Female engineers $n = 49$			Company perspective		
Focus groups: Students from mechanical engineering and adjacent subjects $n = 19$	Interviews: (Former) engineers from mechanical and plant engineering $n = 23$	Focus group: Engineers currently employed in universities $n = 7$	Online analysis of websites and social media profiles $n = 90$	On-site visit of companies of different size and structure $n = 3$	Workshop with representatives of companies and associations $n = 16$

Figure 1: Predominantly qualitative approach to inquire both the female engineers' and the companies' perspective

3.2 Perspective of German Companies in Mechanical and Plant Engineering

In order to include the perspective of companies and to identify possible needs for action, we combined qualitative and quantitative analyses. The quantitative analysis of the web presence of companies from mechanical and plant engineering included the examination of $n = 90$ websites and social media profiles. The analysis focused on how the websites and profiles addressed and presented women, as well as presented topics like work-life balance, sustainability, and digitalization. In addition, we visited three companies from the mechanical and plant engineering sector to assess working conditions on site as well as conducted interviews with employees, HR managers as well as superior managers. The companies varied in terms of number of employees and company structure. The company visits started with a thorough tour through the company offices, then, the interviews took place. The goal of these two phases was to obtain different perspectives for the assessment of organizational design components (Hanna, 1988; Marks, 1991). At the end, we shortly presented and discussed the results of the day with company representatives.

After combining the two perspectives of female engineers and companies, a workshop was held with 16 representatives from companies and associations, including CEOs, senior managers, engineers, and HR managers. The key findings of the study were presented and discussed; participants shared views from their companies and provided input for actionable recommendations. Based on these, the authors finalized the set of implications and recommendations for companies.

4. Results

The present results are part of a broad-based German study commissioned by the IMPULS Foundation (Daling et al, 2023). Interviews and focus groups were transcribed and content categories were generated based on Mayring's content analysis procedure (Mayring, 2010). The results reported below include the findings of both perspectives: female engineers and companies.

4.1 Career Orientation

Many prospective or working female engineers emphasized how important it was to know what their work could look like in the professional world and to experience a sense of purpose in their work. Internships, excursions, and company visits illustrated the practical application of theoretical knowledge and the meaningfulness of working as an engineer. Collaborative thesis projects and studies with companies had similar effects. Several women mentioned that experiencing positive internships made them choose the respective companies after graduation.

What is more, participants stated that exchange in networks and mentoring programs for female students encouraged them to pursue their studies and showcased potential career paths. With their professional experience, mentors can serve as role models and provide advice on current obstacles, decisions, or conflicts. One engineer working in the sector stated: "I already had a supervisor during my internship semester, and I also see my boss here at the company as a kind of mentor. She also studied engineering and is a real role model for me." Making female role models visible emerged as another essential factor to attract young female engineers. "Engineering is still a male subject", stated a head of department in an interview. Female role models could help to change this picture – however, finding them remains a challenge.

Finally, female engineers desired transparency about possible career paths and opportunities they would have in engineering companies: Which career opportunities were (actually) open to them? This included, finally yet importantly, the question of whether the company would allow them meaningful work, even with a family. However, the analysis at companies showed that they struggle to provide such information as well as networking opportunities, or mentoring programs.

While companies acknowledge the importance of recruiting women, they put no focus on it. The misconception prevailed that a focus on female recruiting would prevent men from applying. During the company visits, it was often said that "there are no women on the market". One department head confirmed: "If there is a woman, that's good, but at the moment we can't afford to look only for female engineers. There are hardly any applications coming in." Companies used existing formats like career fairs and job portals but specific efforts for recruiting women were lacking. Further examination showed that companies, especially smaller ones, were hardly using opportunities like participation in networks or mentoring programs.

4.2 Job Search

Our survey emphasized the influence the company's website has on job decisions. However, despite the significance of gender-equitable language, it was found that only nine percent of the websites consistently used such language. It has to be noted that in German, professions have a gender-specific ending. The male form, e.g., "Ingenieur", has been used with the justification that it is generally addressing everybody. However, the female word would require adding a "-in" as in "Ingenieurin". The focus groups showed that female students preferred inclusive language like "Ingenieur_in" in job advertisements. Most job advertisements, on contrary, used male connotations. Additionally, the skills rarely included stereotypically female aspects, such as "cooperate" or "team culture". Often, they used a competitive language despite the fact that an HR manager stated that "cooperation and creative problem solving" are the most relevant skills of engineers.

The web analysis of 90 company websites indicated that many companies predominantly targeted and presented men on their online platforms. The visual design of websites often underrepresented women, affecting female engineers' decisions to apply. The focus groups showed that the presence of women on a company's website was considered encouraging. However, authenticity was most important as an engineering student stated: "Of course, at first, you're happy to see women on the website, but there's often a fine line between 'we really stand up for women here' and hypocrisy. You get treated as something special when all you want is to be treated equally, and sometimes companies go a bit overboard."

Social media played an increasingly important role in a company's self-presentation. They served as information sources and contact points for job seekers, providing insights into the company's work culture and profiles of female employees. The web analysis showed that the larger the company, the more likely it was to use (multiple) social media platforms and actively involved trainees on platforms like Instagram for recruitment. Facebook and Xing (a German career platform), were widely used by companies, LinkedIn and Instagram were less represented (see figure 2) despite being preferred by female engineers.

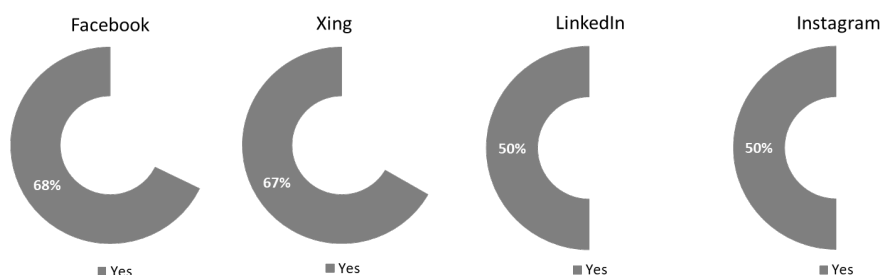


Figure 2: Share of companies who have a social media profile at the respective platform (n = 90)

As a further point, the focus group provided insights into the women's motivation for a doctorate ("Dr. Ing." in Germany). Rather than considering science as a separate career path, many research associates viewed their current employment "[not] as a decision to pursue a different career option than industry, but as an interim phase." as one female researcher stated. Moreover, some women considered the doctorate as a "quality seal" that would manifest their expertise, which some participants seemed to consider necessary for entering a male-dominated industry. Additionally, some participants explained that the scientific field offered more innovativeness, a clearer expert orientation, and options for individual development, comprising easier family planning.

4.3 Job Entry

The prospective and working female engineers underlined that onboarding has an impact on the retention of employees within the company. Well-organized onboarding enables employees to work autonomously and efficiently more quickly, leading to lower turnover and cost reduction.

Many interviewees emphasized the importance of a well-structured and welcoming induction for a successful and long-term engagement. Getting to know various departments and processes within the company helped them connect, identify contacts, and gain a comprehensive understanding of the company's operations. Shadowing in different departments can make this process even easier as one engineering student pointed out in the focus group discussion: "When you start out, there are also different ways to organize the onboarding process. What I always find great [...] is that you simply sit in on different departments". In addition, another student clarified that accessible "buddies" or informal mentors could enhance the welcoming culture and enable a rapid integration: "What would be important to me are clear contacts who can familiarize me with my tasks and are available to answer questions. Not just professionally, but also personally. You could possibly separate that into a professional induction and then perhaps a mentor who establishes contacts in the company or explains what the unofficial rules are". Furthermore, regular feedback meetings, particularly on interpersonal topics such as well-being in the company and integration into the team, made women feel supported and welcome.

Nearly everybody considered working in diverse and varied teams desirable and beneficial for a pleasant work atmosphere during career entry. One working engineer explained: "Male, female, German, international, old, young and so on. So, it's a cross-section where you think: 'That would be so cool if it was like that everywhere'". On the contrary, experienced female engineers reported the impression that they needed to invest more energy to be accepted in less diverse teams, especially when the leadership level was homogeneous. Several participants emphasized that companies would have to promote equal opportunities actively: changing culture and the outdated picture of engineers as men.

Despite several engineering students objecting the implementation of quotas because, as one student stated, they "do not want to get a job because of my Gender", experienced engineers viewed them as a crucial measure to support women in the profession and emphasized the need for a shift in professional culture. Regarding this shift, many students remarked that, when they entered the workforce, feeling accepted and appreciated within the team was particularly important to them. Despite some more experienced engineers' contrary experiences, they wished to be recognized according to their professional competencies irrespective of gender.

5. Discussion

The results of the study provide insights into the facilitating and inhibiting factors of aspiring and working female engineers with regard to the transition between studying and working. They are complemented by challenges and opportunities that arise from exemplary companies in the engineering sector.

A central point in attracting potential and future female engineers concerns communicating a modern picture of the engineering profession. The majority of young women report limited knowledge of what an engineer's job entails, and therefore feel inadequate prepared for their studies and professional life. Companies should focus on communicating the diversity of the engineering profession to young women emphasizing its future viability and innovation, as well as current issues such as sustainability, decarbonization, and its arising purpose. In addition, the profession of a mechanical or plant engineer is not yet sufficiently visible in the everyday lives of young women. To address the target group of young women (and also men), the use of social media will become more relevant for companies in the future.

Another point relates to the expressed need of young girls and women for visible female role models before and during their studies as well as in their professional lives. There are many ways for companies to actively promote role models. They could, for example, reward their (female) employees participation in mentoring programs, increase the visibility of female engineers in university lectures as well as at trade and career fairs. The importance of female role models also plays a central role within the company by demonstrating possible career opportunities to newer employees.

The transition from university to the professional world is a crucial phase in the career paths of female engineers. Previous research has found little information on how female engineers find their way into the profession and which factors they consider when deciding on a domain or a company. The present study provided insights into the strategies and decision-making mechanisms of female graduates. It became evident that companies that provide (positive) opportunities for female students during their studies (internships, field trips, theses, etc.) often manage to recruit these women later. The study also shows that websites and recruitment activities (e.g. fairs, information events, job advertisements) need to be adjusted to address women, too, rather than trying to include them in a general – unintendedly often male – recruitment. Especially smaller companies have hardly been using an active approach to address women in recruitment strategically. As the study showed, respective tools can be small: use visual representation and language to address women, making the working culture tangible, providing insights into teams, being transparent about career steps etc. on websites. However, the observations suggest that increasing the proportion of women in companies is maybe a topic of HR but is not given a high priority across hierarchies. While some are trying, in many companies the topic remains to play a subordinate role on the agenda of managers.

After the application process, the next challenge for female engineers arises at job entry. Some engineers think they can only be accepted with a “quality seal” in form of a doctorate. In order to receive recognition and appreciation, especially at the professional level, many female engineers feel that in order to be accepted they must adapt to the male-dominated professional habitus and prove their abilities more than their male colleagues have to. These mechanisms are deeply rooted in the professional culture of engineering and usually operate unconsciously. Therefore, the conclusions can lead to a certain helplessness if companies want to embrace change. The balancing act between active measures to promote equal opportunities and the (often reasonable) desire of managers not to put female engineers in the spotlight is a big challenge. A clear directive from the top, the sincere will of all involved, and an honest analysis of one's own options are important steps on a marathon of small steps that does not promise quick success.

In addition to the research associates that chose an academic position due to its higher planning security and innovativeness, students mentioned that they wished for transparency on career trajectories and promotion-facilitating factors, also involving the demonstration that the company would allow a compatibility of family and work. For companies, there are several starting points, such as emphasizing the innovative capacity of their own company, offering and agreeing on training goals in the first five years of employment, and emphasizing security through the mostly permanent employment contracts. In addition, companies should actively and credibly promote parental leave – not only for women, but for all employees – as an accepted option and report on respective measures, e.g. attractive part-time opportunities. Particularly for small companies, this topic provides the opportunity to demonstrate their flexibility to find individual solutions. However, whatever companies declare, women are very sensitive in detecting whether corporations really mean it or solely state it for advertising purposes. In order to increase attractiveness, it will be inevitable to reflect on and shape the corporate culture so that the recognition of professional competence happens regardless of gender.

Eventually, limitations of qualitative data have to be considered when interpreting its results. Although the survey of 49 female engineers provided a detailed insight into the expectations and needs of the respondents, their transferability should be further analyzed, for instance with quantitative evaluations. The company visits combined with the workshop with company representatives provided insights into the working conditions of the three companies. However, companies and conditions differ: the observations collected here do not apply equally to all companies in the mechanical and equipment sector, but represent a selection. Finally, the study was conducted in Germany. As mentioned before, the professional habitus of the engineer has a very long tradition in Germany. It is male, conservative, and tenacious. While the results apply to the German professional context of being an engineer and may be transferrable to other western countries, other cultures have different connotations. That is, in other countries both the job profile of an engineer as well as the possible obstacles and challenges for women may differ.

6. Conclusion

While the number of women working as engineers in the mechanical and plant engineering sector in Germany have been remaining at humble levels, the current study provided insights into the reasons for young female engineers to enter the sector – or stay out. Although the diversity of teams surely has many advantages, the current shortage of skilled workers might be one of the driving reasons why German companies realize that they have to attract more women. To use this momentum, the current study addressed the question of facilitating and hindering factors of female engineers with regard to the transition between studying and working as well as for the options of companies in this regard. To this aim, it investigated the women’s perspective as well as the one of companies in Germany.

The results show that a clear recruiting strategy to address women in particular does not require great changes but small steps: adapting the online presence with linguistic, informational, and visual changes. Women – and an increasing number of men – want to work and have a family. The working culture has to overcome the dusty habitus of “the male engineer” but respect competence independently of individual characteristics. Overall it is important that everybody involved approaches the change sincerely. As examples from various companies show, honestly analyzing the current status-quo and going small steps from there will lead to successes in attracting female engineers for working in companies and the sector of mechanical and plant engineering.

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